connection with a secondary cyclone. This cyclone line up in FCC reactors is also referred to as close-coupled cyclone separation provided that the primary and secondary cyclones are contained in one larger vessel. This coupling of primary and secondary cyclones minimises the residence time in which the hydrocarbon product is in contact with the catalyst after it leaves the reactor riser, which limits undesirable aftercracking.

Both in the FCC reactor, as discussed above, and in the FCC regenerator such series of primary and secondary cyclones exist. EP-A-309244 describes an example wherein coupled cyclone separators are both used in the reactor as well as the regenerator vessel. Typically more than one of these series of cyclones exist in parallel. Examples of other processes in which a primary and secondary cyclone arrangements are used are the Methyl tert-butyl ether (MTBE)-fluidized bed dehydrogenation process and in the acrylonitrile process.

There is an on-going effort to improve the separation efficiency of cyclone separation apparatuses.

One known method of improving the separation efficiency of a primary cyclone apparatus is achieved by decreasing the cross-sectional area of either the gas inlet or the gas outlet opening and hence increasing the local gas velocity. Although the separation efficiency of the primary cyclone shows an improvement, the overall efficiency of the primary and secondary cyclone separators is not significantly improved.

One of the objects of the present invention is therefore to provide an apparatus, wherein particles can be efficiently separated from a gas-particles mixture, which has an improved overall separation efficiency.

The invention is also directed to a combined separation and stripping process, wherein a mixture of fluid catalytic cracking catalyst is separated from a

catalyst containing gaseous hydrocarbon effluent of a fluid catalytic cracking (FCC) reactor zone and wherein any hydrocarbons are stripped from the separated catalyst particles in a fluidized bed zone to which a gaseous stripping medium is supplied to.

Such a combined FCC separation/stripping process is described in WO-A-9742275. This publication describes the separation of catalyst particles from a gaseous stream leaving a reactor riser of a fluid catalytic cracking (FCC) process. The separation is performed by making use of a primary cyclone apparatus located in a reactor vessel, in which primary cyclone the gas-solids stream enters tangentially into a vertical tubular cyclone housing. The solids are discharged downwards to a stripping zone located at the lower end of the reactor vessel. A partly cleaned gas stream and part of the stripping gas is discharged upwards through a vertical gas-outlet conduit, which gas-outlet conduit protrudes the cyclone tubular housing from above. The solids still present in the partly cleaned gas obtained are subsequently separated in a secondary cyclone. The lower open end of the tubular primary cyclone housing projects downwards into a fluidized-bed zone present in the lower part of earlier mentioned reactor vessel. Stripping gas is supplied to the main fluidized bed zone. Because the tubular housing of the primary cyclone separator is smaller than the reactor vessel only a part of the stripping gas will enter the tubular primary cyclone housing from below.

US-A-4692311 describes a combined process for separating and stripping FCC catalyst in which all of the stripping gas is discharged through the gas outlet of the primary cyclone separator. This is achieved by using a cyclone having a tubular housing and a single stripping zone located in the lower portion of said tubular

housing. In this manner all of the stripping gas will have to leave the primary cyclone via its gas-outlet. Although this process may look promising regarding the simplicity of the design no large scale working examples have been realised up till now. This is because the separation efficiency is poor when a large flow of stripping gas has to pass through the tubular housing of the cyclone. A similar apparatus as described in US-A-4692311 is described in US-A-5112576.

Cyclone separators having a vertical tubular housing and an gas-outlet conduit having a gas-inlet opening located at about the level of an elevated cyclone roof are described Chemie Ingenieur Technik (70) 6 1 98, pages 705-708.

A next object of the invention is to provide an improved process for the combined separation and stripping of a mixture of fluid catalytic cracking catalyst in a fluid catalytic cracking process, in which the separation efficiency of the catalyst is higher.

These objects and other objects, apparent when reading the description, are achieved with the following apparatus.

Summary of the invention

Apparatus for separating solid particles from a suspension of solid particles and vapour, wherein the apparatus comprises:

(i) a vertical primary cyclone vessel having a tubular housing comprising of a tubular wall section provided with a tangentially arranged inlet for receiving the particles and vapour, and which tubular wall section is open at its lower end and closed at its upper end by means of a cover provided with an opening, wherein the opening is fluidly connected to a gas outlet conduit, which conduit has a gas inlet opening located at the same level as the opening in the cover;